The influence of human resource management practices on learning and innovation: pharmaceutical firms in Mexico

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Abstract

This paper explores the influence of human resource management practices on learning and innovation in the context of developing countries. It focuses in particular, on the contribution of some management practices conditioning learning at the individual level. Firms may choose between three alternative learning strategies: performance of R&D in-house (Internal), acquire technology from external sources of knowledge (External) or a combination of both these strategies. Analysis is supported by multinomial logit regression techniques using survey data about pharmaceutical firms in Mexico. We find that wages and the provision of training by external agents are conducive to learning. Moreover, coincident with the notion of internal absorptive capacity building, the paper suggests human resource management practices may work better whenever firms in the industry combine internal and external learning strategies.

Keywords: Learning and innovation; Human resource management; Mexico
JEL codes: O31, O32, O54

1. Introduction

Innovation is an interactive process of knowledge-creation, diffusion and use. (Lundvall, 1992; Nelson, 1993) Knowledge is generally understood as the accumulated structure of ideas, theories, experiences and practices that provide individuals, organisations and society at large with understanding or meaning to them and their environment. Learning involves a passive dimension where specific responses emerge through engaging in activities unrelated to learning and where causality is not understood. It also involves an active dimension underpinning discovery of underlying reasons beyond events, formulation of mental maps and integration of new constructs into existing cognitive structures. (Polanyi, 1966)

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Firms are the core of systems of innovation. (Nelson and Winter, 1982) As such, they must develop competencies in product design and production, in overall management and assessment of consumer needs and in linking to upstream and downstream suppliers and distributors. They must search, develop R&D 'routines' and further engage in the learning processes for innovation. (Dosi, Freeman et al., 1994) Innovation rests on a given set (endowment) of material resources, human skills and relevant knowledge, but also on the way these are organised and co-ordinated in pursue of firms' strategic goals. (Barney, 1991; Leonard-Barton, 1992)[3] Such factors condition the multiple directions in which information and knowledge flows feed back and forth across production, marketing and sales and notably, R&D activities. (Lundvall, 1988; Lundvall, 1992) Furthermore, they condition the type and strength of interactions that firms establish with other agents in their environment. (Lundvall, 1992; Laursen and Salter, 2004) Learning about firms' internal organisation and work practices is vital to understand the functioning of systems of innovation. (Nelson, 1991; Coriat and Weinstein, 2002)

In this context, recent contributions to literature on innovation suggests that differences in human resource management practices would help to explain diversity in learning and innovation performances between firms, sectors of economic activity or even countries. (Lorenz and Wilkinson, 2003) Consistent theoretical, empirical and comparative work on these matters is still at an early stage though. (Hemmert and Oberländer, 1998; Lorenz and Wilkinson, 2003) A major challenge remains the need to explain the mechanisms thereby human resource management practices influence innovation. (Delery, 1998; Laursen and Foss, 2003) Existing literature hints at ways to address this issue. Research could further explore factors underpinning creativity and the ways in which creative thinking spreads across groups, organisations and the more ample environment in which firms operate. (Amabile, 1996; Mumford, 2000; James, 2002) Alternatively, following recent work by (Lorenz and Valeyre, 2005; Arundel, Lorenz et al., 2007; Lundvall and Valeyre, 2007) on learning, organisational and management practices and innovation, one might need to more carefully look at the relationship between human resource management practices and learning at the individual level. This constitutes the core of this paper.

This paper expects to further our understanding about the influence of human resource management practices on learning and innovation in the case of developing countries[4]. The paper identifies some learning strategies followed by pharmaceutical firms in Mexico. Alternative decisions are between internal development and/or external acquisition of technology. We then inquire about which management practices are likely to condition the choice of specific learning strategies and how they do so. Section 2 discusses learning from and organisational perspective. This sets the framework to address the importance of individuals' learning for the functioning of organisations in Section 3. Section 4 splits in two parts. First, we introduce some lessons learned from recent innovation studies about human resource management practices and innovation. Then we examine some specific practices conditioning individuals' learning. In so doing, we characterise management styles in a country like Mexico. Section 5 characterises pharmaceutical innovation in Mexico. Section 6 describes the data used in

[3] There is however the possibility for these same factors to become a sort of handicap –core rigidities- firms would eventually need to overcome in order to confront new challenges or carry out new projects. (Leonard-Barton, 1992)

[4] For a more ample discussion on the topic see (White, 2002)

this paper, together with the variables capturing learning strategies and potential explanatory variables. Section 7 presents our empirical analysis. Section 8 concludes.

2. Organisational learning

The economics literature often depicts organisations as systems that process information in order to make the appropriate decision in the light of uncertainty. (Casson, 1990; Nonaka, 1994; Nonaka and Takeguchi, 1995) Neoclassical theories of the firm conceive knowledge creation as an input-output problem-solving activity that merely requires adequate processing and that will yield unambiguous solutions. However (Nonaka, 1994) points out that this approach not only underestimates the nature of the activity at stake but excludes the possibility of explaining the potential of firms to create new information and knowledge. Furthermore, to conceptualise organisations as mere information processing devices assumes uniformity in the learning processes across them; something that is certainly not the case.

Organisations have cognitive structures and memories. Over time they develop specific types of behaviour and mental representations which allow perpetuating organisations' social patterns. (Nelson and Winter, 1982) and (Kay, 2000) argue that organisational knowledge or competencies become embedded in organisational routines, who act as organisational memory. These mental representations or routines influence individuals' learning within the organisation and transmit the organisational heritage to new personnel. Indeed, organisations can know less than the aggregation of its members where there is little or poor communication between its members.

(Kessler, Bierly et al., 2000), (Bierly and Chakrabarti, 1996) and (Zack, 1999) point out that organisational learning always involves choices regarding internal and external learning, as often firms need to decide whether to develop their own knowledge or acquire and/or imitate knowledge of others. The main reason to develop internal sources of knowledge is to generate absorptive capacity. (Cohen and Levinthal, 1990) Absorptive capacity refers to the ability to evaluate and use outside knowledge. It is based on the level of prior related knowledge already available in the firm, including basic skills as well as recent technological and scientific developments in specific fields. The rationale underlying the notion of absorptive capacity is that the more objects, patterns and concepts already stored in the organisational memory, the more readily is new information about these constructs acquired and the easier it is to use them in new settings. This is so because learning often takes place through association with patterns, situations or events already recorded in the organisational memory. Absorptive capacity arises out of previous knowledge accumulation and the intensity of current learning efforts by the firm and its members.

External sources of knowledge in turn, bring fresh thinking and provide a benchmark for internal efforts. Sources of external knowledge do not limit to other organisations but include external publications, universities, research institutes, government agencies, consultants and professional and personal networks. Indeed, (Kim, 1998; Kim, 2000) develops an international dimension to this argument by pointing out that external knowledge acquisition and imitation can also be done across national systems of innovation.

3. Individuals' learning

Knowledge creation within organisations is a complex cumulative multilayered process. It begins at the individual level, as employees are the building blocks of any organisation. (Nelson and Winter, 1982; Simon, 1991; Nonaka, 1994; Nonaka and Takeguchi, 1995) Indeed, (Simon, 1991) suggests that organisations only learn through the learning of its members and/or by employing new members that add knowledge previously unavailable within the organisation. The cognitive potential of an organisation is to an important extent, determined by the accumulated skills and knowledge of its individual members. (Nelson and Winter, 1982)

The literature on cognitive and behavioural sciences points out that individual learning involves a process of continuous creation, destruction and recreation of cognitive structures. (Fiol and Lyles, 1985; Fiol, 1994; Ambrosini and Bowman, 2001) Individuals scan the environment for information; select, prioritise and adapt what they find; interpret their findings; and apply them to their existing cognitive structures. (Lane and Lubatkin, 1998) (Fiol, 1994) points out that this process need not be conscious or intentional and does not necessarily immediately modify behaviour but rather leads into a new interpretation or meaning of available information. A comparison of different interpretations takes place until achieving a new understanding of the issues at stake. All dimensions of learning feed on each other and result in a series of loops and interactions that are difficult to explain by individuals within organisations but are clearly undertaken.

(Vinding, 2006) suggests that the extent, level and quality of knowledge available in organisations' personnel is positively correlated with the size of the stock of knowledge feeding organisational learning, which in turn allows for better judgement as to the search, selection and analysis of even newer internal and external information. Education is one of the key inputs for building individuals' expertise, some of which can be codified into articles, books, drawings or other forms of storable figurative communication. Yet, good education is not sufficient to build an advanced level of individual knowledge. (Brusoni, 2002) and (Loasby, 2002) assert that the application of the principle of division of labour to knowledge resulted in specialisations along disciplinary, functional or institutional lines and the emergence of scientific knowledge that has increased the productivity of knowledge and provided frameworks and focus for addressing a variety of issues. The more individuals advance in their areas of specialisation the more the expertise they acquire and the larger their potential contribution to organisational knowledge. (Cohen and Levinthal, 1990) and (Lundvall and Johnson, 1994) expand the role of knowledge specialisation by arguing that expertise does not only involve substantive technical know-how but also entails where to find the necessary complementary knowledge, including knowing who has the relevant information.

Individuals' knowledge and learning skills can be substantially augmented by what (Amabile, 1997) calls 'something extra' or creative thinking. Creativity is defined as the production of novel ideas in any domain and creative thinking refers to a 'cognitive style favourable to taking new perspectives on problems, an application of techniques (or "heuristics) for the exploration of new cognitive pathways, and a working style conducive to persistent, energetic pursuit of one's work'. (Amabile, 1997) (Sternberg,

O'Hara et al., 1997) allege that creativity requires being in the frontier of available knowledge; the combination of synthetic, analytical and practical abilities; an independent thinking style; intense motivation and persistence in pursuing an idea; a risk taking personality; and, an environment conducive to exploration.

The importance of individual knowledge for organisational learning is further underscored by the fact that a significant part of the knowledge accumulated by individuals is tacit. (Polanyi, 1966; Nonaka, 1994; Nonaka and Takeguchi, 1995) Tacit knowledge refers to meaning acquired through experience and is difficult to formalise or communicate. Tacit knowledge emerges during the actions and activities that individuals undertake along their life and relates to the context in which these take place. Indeed, the more diverse the experiences the richer the content of tacit knowledge. (Nonaka, 1994) and (Nonaka and Takeguchi, 1995) state that tacit knowledge involves both cognitive structures based on mental models that provide overall positive and normative perspective to actions and activities as well as technical elements based on concrete know how and practice under specific circumstances. Tacit knowledge is the foundation of individual skills. (Nelson and Winter, 1982)

(Nonaka, 1994) and (Nonaka and Takeguchi, 1995) add that individuals' 'intentionality' or the willingness to practice the search for meaning in their environment in order to understand and improve it, is critical to the enhancement of individual knowledge. In their view, intention and freedom are major forces motivating individuals to expand their individual knowledge. (Kim, 1998) complements this view by pointing out that in addition to motivation, or perhaps a consequence of it, the intensity of effort, or the amount of energy put by individuals into solving problems, constitutes a major driver in the construction of meaning in organisations.

In sum, individuals are the beginning and a major source of organisational knowledge and learning. Through exploring issues, education and training, creative thinking, experiences and beliefs, expertise and relationships, intentions and freedoms and intensity of efforts, individuals contribute to the making of innovations within organisations.

4. Human resource management, learning and innovation

In recent year, innovation literature has devoted significant efforts to more systematically explore the influence of human resource management practices on learning and innovation performances. (Michie and Sheehan, 1999; Laursen and Mahnke, 2001; Greenan, 2003; Laursen and Foss, 2003; Lorenz and Wilkinson, 2003; Michie and Sheehan, 2003; Campos and Pina, 2004; Arundel, Lorenz et al., 2007) In effect, calls are to frame these studies within the notion of systems of innovation. (Lundvall, Johnson et al., 2002) Recent empirical work steams mostly from surveys of firms in developed countries. So far, issues under investigation include the impact of labour market deregulation and labour flexibility on innovation, together with the search for complementarities between human resource management practices underpinning innovation. (Michie and Sheehan, 1999; Laursen and Foss, 2003; Michie and Sheehan, 2003) These studies assert that even if individual management practices may enhance creativity and innovation, interventions are complementary, mutually reinforcing; hence, better used as part of coherent incentive systems. (Michie and Sheehan,

1999,Laursen, 2003 #190) Furthermore, the more innovative the system of human resource management practices adopted, the larger the likelihood a firm would carry out and be productive in innovation. (Michi and Sheehan, 1999, 2003) Consequently, "If firms adopt work practices in a complementary fashion, then empirical tests should consider the impacts of groups of practices rather than simply the effects of individual practices." (Ichniowski, Shaw et al., 1997)

Characteristics and influence of management practices may be contingent on firms' industry or sectoral affiliations. (Laursen and Foss, 2003) Firms featuring different innovation strategies or operating in completely different sectors would benefit distinctly from adoption of even comparable management practices. (Laursen and Mahnke, 2001) Moreover, one should carefully consider the characteristics, requirements, challenges and opportunities associated with differences in the knowledge bases in which firms operate. The peculiarities of innovation processes in an industry are likely to influence the linkages between human resource management and innovation. (Chiesa, 1996; Hara, 2003)

4.1 Management practices

Bringing together all the above discussion, here we identify some human resource management practices conditioning individuals' and thereby organisational learning. Relevant interventions include training, compensation or remuneration, incorporation of workers in decision making processes, rotation programmes and management-workers communication through, for example, unionisation practices. Analysis of the characteristics of such interventions in Mexico sets the ground for the empirical analysis in subsequent sections in this paper.

Training supports development of technical skills but also managerial and interpersonal skills for planning, decision making, organisational development and so on. (Sparkes and Miyake, 2000; Barton and Delbridge, 2001) In practice, two main forms of training are available: on-the-job and off-the-job training. As for the first type, it goes beyond formal knowledge acquisition; it involves reflection on learning and learning through problem-solving. (Gray, Cundell et al., 2004) The second type of training may take place through formal external –classroom- education and notably, by linking to external knowledge producer organisations. (Casas, 2001; Okada, 2004) Studies about Mexico and other Latin American countries document the importance of training in addressing motivational problems affecting blue-collar workers facing both extremely low levels of education and limited development opportunities. (Colmenares, 1992; Garcia, 2002) Frequent problems result however, from poor formalisation of training structures, mismatches between training and promotion, enhanced independence, authority and responsibility. (Dominguez and Brown, 1998; Samstad and Pipkin, 2005) This is together with low incentives for training, incompatibility with work-schedules, inappropriate conditions for new skills to be put in place and high post-training turn-over. (Abramo, 1997; Carrillo and Ramirez, 1997; Garcia, 2002; Islas, 2003) Training is the main factor linking firms with knowledge producer institutions such as universities and public research centres in Mexico. (Casas, 2001)

The type of incentives and how they are administered condition diverse motivational styles and thereby people's attitudes towards work. (Badawy, 1988; Florida and

Goodnight, 2005) Usual recommendation from the literature is to provide a mix of both intrinsic -greater autonomy, additional developmental opportunities, public recognition, etc.- and extrinsic rewards -pay increases, promotions, etc. (Mumford, 2000; James, 2002) In the context of countries like Mexico characterised by tight markets for skilled-labour, compensation mechanisms are instrumental to attract, motivate and retain personnel. (Flynn, 1994; Stephens and Greer, 1995; Abramo, 1997; Dussel, 2003) Adequate individual rewards would motivate Mexican workers to excel in their jobs. (Forest, 1994) In Mexico the concept of payment per-hour is seldom provided and even faces serious constraints under both local labour laws and customary union practices. (Flynn, 1994; Sargent and Matthews, 1997; Samstad and Pipkin, 2005) Setting up monthly remunerations is the general practice. Compensation packages usually include something more than nominal wages. Non-pecuniary often 'status enhancing' forms of compensation are highly appreciated particularly at higher levels of responsibility and skills. (Flynn, 1994; Stephens and Greer, 1995) As noted earlier, wage and general compensation in the pharmaceutical industry is considered among the best in Mexico. This is in a context where wage contention policies have traditionally being instrumental to contend inflation and underpin industrial competitiveness.

Notable among innovative management practices is decentralisation of both decision-making and problem-solving rights. (Zanko, Couchman et al., 1998; Laursen and Foss, 2003) Whenever decision-making flows down together with relevant knowledge, tools and incentives, it opens up possibilities for individuals to influence and participate in the design and operation of work environments, to adapt or respond to emerging challenges and opportunities for innovation. (OECD, 1998; Zanko, Couchman et al., 1998; Mumford, 2000) In contrast to the previous discussion, in general labour relations in Mexico are regarded as highly hierarchical. (Carrillo and Ramirez, 1997; Garcia, 2002) Power would flow top-down based on paternalism, links of trust and loyalty between workers and immediate supervisors. (Forest, 1994; Schuler, Jackson et al., 1996; Muller and Rowell, 1997) Delegation of responsibility would limit to particular tasks and often go without decision-making authority and resistance to follow-up and control. (Martinez and Dorfman, 1998) This notwithstanding, some studies document some successful empowerment experiences particularly in contexts other than maquiladoras. Arguably, difficulties for Mexican workers to assume higher responsibilities and more importantly, to participate actively in processes of organisational or technical change steam from their low qualification and schooling attainments. (Abramo, 1997) Highly-skilled Mexican workers, notably those working for some MNC affiliates and 'high-standard' Mexican companies, would be less inclined to traditional work styles. (Rao and Teegen, 2001) Particularly at managerial levels, they would show strong work ethics, willingness to work for long hours, assume extraordinary responsibilities and so on. (Stephens and Greer, 1995)

Literature identifies rotation assignments as suitable to promote increased knowledge diffusion within the organisation. (Mumford, 2000; Laursen and Foss, 2003) By exposing people to the broader organisation, rotational positions may support programme development and implementation, provide group interaction and minimise friction and conflict. (Mumford, 2000; Laursen and Foss, 2003) Rotation assignments in Mexico -and presumably other Latin American countries- would be tied by strong task-specialization associated to assembly processes. (Garcia, 2002) Strong standardization of jobs and processes, inputs, behaviours and outputs would act against positive effects of this innovative human resource management practice. (Jones, 1996)

Available innovation studies in the field customarily test for the effect of trade unions on the probability of a firm being an innovator. (Ichniowski, Shaw et al., 1997; Michie and Sheehan, 1999; Michie and Sheehan, 2003) In practice, indicators include the presence of formal procedures to fill-in grievances or the frequency of strike actions. Evidence on the real impact of these practices remains rather inconclusive though. In the Mexican context, our expectation about the effects of unions on innovation performance tends to be negative. Available studies stress that local managers would often recognise unions as a major obstacle to implement organisational and technical change; management-union communication and negotiation would be rather poor. (Abramo, 1997; Garcia, 2002)

5. Pharmaceutical innovation in Mexico

This section briefly characterizes pharmaceutical innovation in Mexico. In general terms, pharmaceutical innovation comprises four major stages: (1) Discovery or basic research leading to identification of new molecular targets -"New Chemical Entities (NCE's)-[5]" and pre-clinical studies;[6] (2) Clinical research including activities before and post-marketing of new drugs; (3) Regulatory processes of evaluation and eventual approval/rejection of applications to test, develop or commercialise pharmaceutical products; and, (4) Manufacturing, marketing and product life-cycle support. (Hara, 2003) The length and sequencing of each stage depends on legal, ethical, scientific and economic factors. (Jungmittag, Reger et al., 2000; Gaudillière, 2004) Participation of developing countries in pharmaceutical innovation is more notorious from the later instances of Stage 2 -clinical trials Phases III-IV- onwards. Innovations are mostly incremental and take place within manufacturing and product life-cycle support.

Mexico ranks among the top 10 largest pharmaceutical markets in the world and 2nd in Latin America. Strong dynamism reflects in private retail sales of around US8.7 billion; annual growth rates reach 6.0-8.0 per cent. (IMS-Health) The country is a relevant manufacturing and export base to Latin America and at a lesser extent, the US, Europe and Asia. Local industry investments average US$150 million in plant modernisation, technological upgrading and clinical research every year. (AMIIF, 2005) It also distinguishes for high labour specialisation requirements and larger salaries compared to other industries in the country. International organisations specialized in studies of work environment and job satisfaction systematically place pharmaceutical firms among the selected group of ´best places to work´ in Mexico. (GPWI) This is the case over the last five to six years.

Global multinationals dominate the local market. They are the more dynamic in terms of investment, technological and research performances. (Katz, Burachik et al., 1997; Guzman, 2005) Multinationals manufacture and export finished products with quality and safety standards comparable to those in developed countries. Production scales may be much lower though. They concentrate on the more lucrative Mexican private retail

[5] NCE's are totally new drugs which in most cases represent significant therapeutic advances as 'chemical structures never previously available to treat particular disease(s)' (FDA)

[6] Pre-clinical studies in animals (*in vivo)* or other models (*in silico)* assess toxicity and other pharmacokinetic properties of prospective NCE's before tests in humans can begin. Similar tests however, are performed in humans during clinical research. (Zivin, 2000)

market. In contrast, local firms focus on the manufacturing of generic drugs and depend strongly on sales to the public health sector. (Dussel, 1999) There is however, a clearly identified segment of dynamic domestic firms. As generics manufacturers they have slowly developed capacities to perform some basic research, particularly by incorporating biotechnology techniques. More importantly, they base growth strategies on more systematic innovative efforts. This is the case of firms such as Probiomed®, Bioclon/Laboratorios Silanes™ and Laboratorios Sophia™.

Arguably Mexico has real albeit poorly exploited capabilities to imitate and generate innovative pharmaceutical products. (Guzman and Viniegra, 2005) The country possesses facilities for new drug development and basic research particularly in public research institutions. Activities in those areas remain limited though. Most innovations are of incremental nature: new formulations (43%), improved processes (31%) and quality enhancements (21%). (SS, 2005) All the above seems to corroborate (Cimoli, 2002)'s view of Mexico as an internationally competitive "modernised assembly factory". The fairly complex structure of the pharmaceutical industry in Mexico -and other of the larger Latin American countries-, raises questions about the capacity of local markets, and particularly domestic firms to further strengthen their technological efforts. (Katz et al 1997) To what extent such features contribute to further develop the base of human resources for innovation in the country? Dearth of sufficiently and adequately qualified human factor remains a major shortcoming for the local industry. (Guzman, 2005)

6. Data and descriptives

Table 1. Summary statistics for the Pharmaceutical industry in Mexico, 2004

Num. of establishments 111	Mean	SD[1]	Min	Max
Employment	439.8	500.7	1.1	3391.5
Total sales[3]	631,227.5	1,156,629	2,394	6,958,020
Share of domestic sales	0.9	0.1	0.3	1.0
Share of exports	0.1	0.1	0.0	0.7
Share of foreign capital	25.1	41.5	0.0	100
Years in operation[2]	31.5	18.8	0	74

Notes: 1. Standard Deviation. 2. Difference between the year in which a firm started operations in current business and, the year of recollection of the survey, 2004. 3. Thousand Mexican pesos.
Source: Authors with information from ENESTyC, 2005

Data in this paper comes from the *Encuesta Nacional de Empleo, Salarios, Tecnología y Capacitación* [National Survey of Employment, Wages, Technology and Training] (ENESTyC) This is a national survey carried out by the *Instituto Nacional de Estadística, Geografía e Informática* (INEGI) on behalf of the *Secretaría del Trabajo y Previsión Social* (STPS) ENESTyC is based on a stratified sample of manufacturing establishments in Mexico. Stratification is based on total employment. Firms with 100 or more employees are included "with certainty" plus a random sample of firms with less than 100 employees. There are no fixed time frames to run the survey. Six waves have been carried out so far: 1988, 1992, 1995, 1999, 2001 and 2005. We used data

from the event 2005[7]. The module for the pharmaceutical industry (NASCI code 3254) includes 141 establishments, representative of 388 establishments in total. Our effective sample without missing values is 111 establishments. Table 1 provides some descriptive statistics about the industry.

6.1 The dependent variable

Construction of the dependent variable followed (Veugelers, 1999; Cassiman and Veugelers, 2005) These authors departed from traditional transaction cost theory for which choices of internal and external sources of technology acquisition are mutually exclusive. (Williamson, 1975; Williamson, 1985) They challenged this notion however by bringing in to the discussion two ideas from the literature. In the one hand, development of technological capabilities in-house may give firms substantial 'bargaining' and exchange powers in external technology markets. In the other hand, firms would need to build adequate 'absorptive capacity' in order to screen the market and properly exploit newly acquired technologies. (Cohen and Levinthal, 1989) They therefore suggest the potential to treat internal and external innovation strategies as complementary; at least, as non-mutually exclusive.

From above, our characterization of a firm's learning strategy distinguishes between two different knowledge inputs. First, firms may do R&D in-house and develop their own technology. We take into account R&D for the design of new product and and/or new processes (design of machinery and equipment for own use). We call this a firm's *INTERNAL* learning strategy. Alternatively, firms may obtain technology from external technology markets. This is by means of the purchase of technology packages, acquisition of machinery and equipment, hiring consultant firms, accessing specialized literature or events, training, hire away skilled personnel. Notably, firms may carry out R&D in partnership with other agents. (Cassiman and Veugelers, 2005) Aggregation of these activities shapes the *EXTERNAL* learning strategy. A firm is active learner from external sources whenever it performs at least one of these activities. *INTERNAL* and *EXTERNAL* may be used together. Table 2 summarizes the learning behaviour of firms in our sample.

[7] The latest publicly available edition of the ENESTyC corresponds to the event 2001. Preliminary data for the event 2005 - with information for 2000- can be used previous authorization by INEGI.

Table 2. Definition of the variables composing the learning strategies implemented by pharmaceutical firms in Mexico and correlations

	Variable construction	Firms without missing values (N=111)	1	1.1	1.2	2	2.1	2.2	2.3	2.4	2.5	2.6	2.7
1. *INTERNAL*	1 if firms perform R&D for new product and/or process in house. 0 otherwise	70 (63.1%)	1										
1.1 Design new products	1 if firms declare the goal of R&D in house is the design of new products.	69 (62.2%)		1		0.32*							
1.2 Design new machinery & equipment for own use	1 if firms declare the goal of R&D in house is the creation of new machinery & equipment for own use. 0 otherwise. We take this an indication of new process.	21 (18.9%)		0.33*	1	0.46*							
2. *EXTERNAL*	1 if firms acquire technology through at least one of the following forms of contact with external agents. 0 otherwise:	69 (62.2%)	**0.48***			1							
2.1 Technology package	1 if firms acquire packaged technology. 0 otherwise	30 (27.0%)	0.34*				1						
2.2 Consultant	1 if firms hire consultants. 0 otherwise	28 (25.2%)	0.23				0.67*	1					
2.3 Literature	1 if firms access to specialized literature in their field. 0 otherwise	37 (33.3%)	0.42*				0.34*	0.43*	1				
2.4 External training	1 if firms make use of external agents for the provision of training. 0 otherwise	28 (25.2%)	0.14				-0.03	0.19	0.07	1			
2.5 Knowledge acquisition	1 if firms carry out different activities with other firms in the industry. The objective is to learn about business environment and other features of the industry. 0 otherwise	9 (8.1%)	0.09				0.12	0.21	0.07	0.21	1		
2.6 Machinery acquisition	1 if firms acquire machinery and equipment. 0 otherwise	15 (13.5%)	0.19				0.29*	0.38*	0.17	0.38*	0.37*	1	
2.7 External R&D	1 if firms perform R&D in collaboration with external agents. 0 otherwise	29 (26.1%)	0.37*				0.28*	0.22	0.19	0.36*	0.35*	0.42*	1

Notes: * Different from zero at 1% level of significance
Source: Author based on data from ENESTyC, 2005, INEGI.

A relevant share of pharmaceutical firms claimed to perform R&D in-house (63.1%) Those active in external markets for technology were almost the same in number (62.2%) Distribution by specific mean of external technology acquisition is fairly diversified. Yet, recourse to specialized literature seems to be the most important item, (33.3%) As expected, Internal and External learning strategies are positively and significantly correlated (0.48) These results are consistent with (Cassiman and Veugelers, 2005)'s proposed complementarity between learning strategies. The different external means for knowledge-acquisition are also positively correlated. Looking at the frequency with which firms combine learning strategies, Table 3 depicts a high number doing both Internal&External strategies (50.5%) About 12.6% choose Internal only, while 11.7% choose an External only strategy. A quarter of firms in our sample failed to pursue either of these learning strategies.

Table 3 Frequency of choice of learning strategy by Pharmaceutical firms in our sample

Learning Strategy	Freq.	Percent	Cum.
No internal or external	28	25.2	25.2
Internal	14	12.6	37.8
External	13	11.7	49.6
Internal & external	56	50.5	100.0
Total	111	100	

Notes: Categories are exclusive. This sample includes only firms without missing values for all variables included in the analysis.
Source: authors with information from ENESTyC, 2005.

6.2 The explanatory variables

This paper argues that a better understanding of the relationship between human resource management and innovation requires tracing the links between those practices and learning at the individual level. Following our discussion in Sections 2-4, and contingent on the data available from ENESTyC, Table 4 depicts the potential explanatory variables entering the subsequent empirical analysis. In the interest of space, the table includes original variables in levels only. However, a number of interaction terms between these variables were tested for significance during the analysis. Correlations among these variables are presented in Table 5. The Table includes some interaction terms too.

ENESTyC pays great attention to variables about training. In line with available innovation studies, we distinguished between internally and externally provision of training. (Laursen and Foss, 2003) The internal provision is carried out by personnel attached to the firm. The external category denotes recourse of training by linking to other agents in the Mexican system of innovation. The latter include universities but also some specialised sources attached to the industry. We expect some positive and significant effect of training on the choice of learning strategy.

Section 4 highlighted the practice of setting salaries on a monthly basis in Mexico. We calculated an indicator of this type and introduced it in logarithm form. We

complemented the analysis with the presence of an explicit regulation about benefits paid by the firm. We expect positive effects of these variables on individuals' learning.

Table 4. Dependent and control variables included in the analysis*

variable	Number of firms in sample without missing values		Description
	Learning strategy		
	Internal	External	
Explanatory human resource management practices			
external_tr	60	58	1 if the firm provides external training to its workers and 0 otherwise. This is in connection with at least one of the following organizations: specialized public job training centres, public university, private university, other firms (suppliers) or the industry's trade organization
tr_internal	59	58	1 if training is provided by people in-house and 0 otherwise
avg_wage**	23.0	370.2	Average wage per worker. Average wage per worker calculated by dividing total annual remunerations by average total employment during that same year. We normalize this variable by applying a natural logarithm transformation.
benefit_ir	25	24	1 if the firm has clearly defined internal regulations to set benefits for its employees. 0 otherwise
empower1	30	31	1 if the firm incorporates workers in decision making and it declares that the practice is important. 0 otherwise
rotation1	35	38	1 if the firm possesses a clearly defined regulation about employee rotation assignments. Regulation may be established through collective contracts or nay other type of internal practices. 0 otherwise
union	54	51	1 if there is a trade union inside the firm. 0 otherwise
Control Variables			
justintime1	26	30	1 if the firm declares that it implements just-in-time management practices. 0 otherwise
totalq1	47	50	1 if the firm declares that it implements total quality management practices. 0 otherwise
size1	1=33	1=28	1 if the firm is large sized
	2=37	2=41	2 if the firm is medium or small or micro sized
export1	43	38	1 if the firm exports and 0 otherwise
fdi	20	19	1 if the firms have foreign capital in total social capital. 0 otherwise

*We only include variables in levels. A few interactions were also tested during the analysis. **Refers to the minimum and maximum average wage in 1000 MX$ per year.

The indicator for workers' empowerment is whether the firm incorporates workers in decision making processes. The expectation is to obtain a positive effect on learning, even though we have acknowledged the possibility of obtaining negative results. A similar situation occurs in the case of rotation assignments. Last but not least, we introduced a dummy variable denoting the presence of a union in the firm. This is expected to affect negatively on the learning activities inside the firm.

We incorporate some controls standard in the literature. These take into account differences in terms of size, foreign ownership and the export behaviour of firms in our sample. We also consider the presence of modern organizational practices such as just-in-time and/or total quality management.

Table 5. Pairwise correlation between independent and dependent variables included in the analysis

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	nat_train1	1															
2	external_tr	0.774	1														
		0.000															
3	tr_internal	0.700	0.300	1													
		0.000	-0.001														
4	ln_avg_wage	0.283	0.206	0.218	1												
		-0.003	-0.030	-0.021													
5	empower1	0.030	0.101	0.039	0.066	1											
		-0.754	-0.293	-0.683	-0.494												
6	rotation1	0.076	0.151	0.080	0.080	0.620	1										
		-0.427	-0.115	-0.406	-0.404	0.000											
7	union	0.237	0.221	0.236	0.158	-0.140	0.003	1									
		-0.012	-0.020	-0.013	-0.097	-0.144	-0.978										
8	justintime1	0.081	0.080	0.112	0.028	0.571	0.585	-0.207	1								
		-0.400	-0.405	-0.244	-0.771	0.000	0.000	-0.030									
9	totalq1	0.048	0.114	0.097	0.104	0.508	0.543	0.012	0.407	1							
		-0.620	-0.233	-0.312	-0.279	0.000	0.000	-0.898	0.000								
10	mod_org2	0.066	0.117	0.139	0.135	0.502	0.525	-0.029	0.520	0.924	1						
		-0.489	-0.220	-0.145	-0.157	0.000	0.000	-0.763	0.000	0.000							
11	fdi	0.173	0.071	0.254	0.508	0.180	0.145	0.173	0.125	0.144	0.180	1					
		-0.069	-0.459	-0.007	0.000	-0.059	-0.130	-0.070	-0.191	-0.131	-0.059						
12	export1	0.235	0.120	0.252	0.622	0.083	0.015	0.140	0.048	0.104	0.140	0.546	1				
		-0.013	-0.210	-0.008	0.000	-0.389	-0.873	-0.142	-0.617	-0.275	-0.142	0.000					
13	size1	-0.403	-0.278	-0.264	-0.513	-0.038	0.063	-0.084	0.006	0.114	0.065	-0.393	-0.277	1			
		0.000	-0.003	-0.005	0.000	-0.690	-0.510	-0.381	-0.948	-0.233	-0.500	0.000	-0.003				
14	emp_modorg	0.016	0.090	0.030	0.081	0.981	0.603	-0.152	0.587	0.536	0.531	0.193	0.103	-0.054	1		
		-0.866	-0.346	-0.758	-0.399	0.000	0.000	-0.112	0.000	0.000	0.000	-0.042	-0.282	-0.572			
15	fdiexpt	0.146	0.049	0.238	0.518	0.131	0.103	0.152	0.073	0.116	0.155	0.958	0.597	-0.393	0.144	1	
		-0.125	-0.609	-0.012	0.000	-0.170	-0.280	-0.111	-0.445	-0.225	-0.105	0.000	0.000	0.000	-0.132		
16	exptsize	0.115	0.043	0.178	0.441	0.028	0.006	0.163	0.018	0.132	0.133	0.352	0.895	0.082	0.046	0.396	1
		-0.229	-0.652	-0.062	0.000	-0.768	-0.952	-0.087	-0.850	-0.166	-0.163	0.000	0.000	-0.393	-0.629	0.000	

Test of significance printed within brackets below the correlation coefficient. For variable definition, see Table 4

7. Research strategy and results

The dependent variable in this paper is categorical. It denotes three possible choices of learning strategy: Internal only, External only and the combination of Internal and External. The choice of doing neither Internal nor External types of learning strategies is our reference category. A suitable econometric approach to deal with unordered categorical variables is multinomial logit analysis. (Wooldridge, 2001; Greene, 2003) Following (Hosmer and Lemeshow, 1989), to identify a suitable model we implemented a stepwise method to select the proper definition of relevant explanatory variables. First we classified potential variables in several groups according to the literature: training, remuneration, empowerment, rotation, etc. Next we ran a series of univariate multinomial logit models to perform a forward selection process. We selected only those variables having the strongest potential explanatory power on the choice of learning strategy.[8] Variables entered the subsequent analysis according to their ranking within each relevant group. We also tested interaction terms among variables. In this regard, controlling size and foreign ownership was best carried out when normalised by whether a firm is present in export markets or not. This was captured by variables fdiexpt and exptsize. Likewise, decision making participation provided the more relevant information in association with the combined adoption of modern organisational practices by the firm: just-in-time and total quality management.

Hausman tests for the Independence of Irrelevance of Alternatives (IIA) failed to reject the null hypothesis that IIA holds among the alternative learning strategies[9]. Therefore, specification of a multinomial logit seems adequate for the data. Table 6 reports the results of the model in terms of odds ratios[10].

Looking at the goodness of fit of the model, this is significant at the 1.0% level. The computed log-likelihood ratio (-110.6) is above the critical value of the X^2 statistic at the 1.0% level of significance with 21 degrees of freedom. The value of the Cox & Snell R^2 is 0.341. Moreover, the value of the Count R^2 of 0.64 shows an acceptable predictive power of the model. Predicted probabilities nearly matched actual distribution of each choice of learning strategy in Table 3: Internal only, 13.5%; External only, 11.3%; Internal and External, 54.6%; and, neither type of strategy, 20.6%. Larger deviations correspond to the latter two possible outcomes though. The values of both the Cox & Snell R^2 and the Count R^2 are above usually acceptable values for qualitative dependent variable models in the context of innovation studies. (Amara and Landry, 2005)

As for the impact of our human resource management indicators on the choices of learning strategies, results are as follow: As for the Internal only type of learning strategy, the variable

[8] More specifically we computed a G-test, where:
G=-2(L(c)-L(xi)), L(c) is the log likelihood ratio for the constant only model
L(xi) is the log likelihood ratio for the multinomial model with independent variable(s) Xi, i=1,...,n
G is approximately distributed as a X2 with n-degrees of freedom. Variables considered for the analysis where those for which probability of the G-test was smaller or equal than the critical value of 0.15. For a further discussion see (Hosmer and Lemeshow, 1989) Additional check-ups to find the most suitable model included those suggested in (Long and Freese, 2006)

[9] Computation of the Hausman test involved combination of parameter estimates and associated (co)variance matrices.

[10] We tried alternative specifications of the model with no substantial changes in the results. Wages and external training tended to remain positively significant. These are available from the authors upon request.

on remunerations is the only statistically significant. Moreover, the expected effect is large and positive. All the rest being constant, the odds of a firm having an internal learning only strategy, relative to having none at all are larger by a factor of 4.6 per unit increase in the log of average remunerations. In other words, the likelihood of a pharmaceutical firm being inclined to perform R&D in-house increases with the level of remunerations it pays.

Table 6. Results Multinomial Logit Model

Variable	Choice of learning strategy		
	Internal	External	Internal&External
Training set			
external_tr	2.275	1.430	6.665***
	(1.594)	(0.947)	(4.497)
tr_internal	2.088	2.437	3.344*
	(1.660)	(1.819)	(2.078)
Remuneration set			
ln_avg_wage	4.570**	2.170	3.037**
	(2.788)	(1.514)	(1.694)
Empowerment set			
emp_modorg	0.708	0.913	3.054*
	(0.600)	(0.711)	(1.837)
union	0.429	0.235**	0.755
	(0.367)	(0.150)	(0.462)
fdiexpt	0.132**	0.571	0.0530***
	(0.136)	(0.520)	(0.0488)
exptsize	2.604*	1.099	2.580**
	(1.383)	(0.685)	(1.165)
Baseoutcome (No internal/External)			

N	111	ML (Cox-Snell) R^2	0.341
Log Likelihood Full model	-110.6	Count R^2	0.640
$X^2(21)$	39.90		
p-value	0.008		

Estimation based on Huber/White/sandwich estimator. Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1

In contrast, none of the management practices included in the analysis seems to matter for a firm performing an External only learning strategy. This is with the exception of the presence of a labour union. And then, unionisation would have a negative effect on the odds of a firm being an active learner exclusively from external sources of technology.

The combined adoption of Internal and External types of learning strategies reinforces the previous conclusion about the relevance of wage compensation. Again, the variable turns out positively significant. All the rest being equal, it is expected that the larger the salaries, the larger the odds of a firm being active in the generation and/or acquisition of technology from both internal and external sources. This is relative to the alternative strategy of doing nothing at all.

Provision of external training gains importance for a combined learning strategy. The odds of a firm performing R&D in-house or sourcing knowledge from external technology markets, relatively to the option of doing nothing at all, increase by a factor of 6.7 times whenever it links to external training providers. This finding reinforces the aforementioned conclusion by (Casas, 2001) about training as a meaningful reason for firms to interact with other agents in Mexico. Arguably, linkages with universities and public research centres would be more and more important as firms try to move up in the construction of R&D capabilities. If we rearrange the effect of training by alternative outcomes, we corroborate the contribution of external training. It does suggest for example, the necessary availability of an internal knowledge base to be able to assimilate knowledge from external resources. External training raises the likelihood of a firm performing a combined learning strategy by a factor of 4.7, relative to the option of exclusively learning from external sources of knowledge.

As a further check about the importance of learning, we ran two additional models similar to the one shown in Table 6. In the first case we kept only the definition of internal training and, in the other, we introduced an interaction term between internal and external training, meaning, we looked at firms strictly providing both types of training. In either case, the alternative definitions of training remained significant. In the case of the model with the interaction variable, a new variable gained some significance, i.e. the interaction term between decision making and the use of modern organisational practices. This gain in significance however, was somewhat marginal and at the expense of a slight lost of predictive power in the model.

We could not find a model in which rotation and empowerment practices were statistically significant. Introducing the variable about benefits' regulation rendered some positive results in terms of significance. The overall fit of the model tended to be somewhat poorer compared to the one shown in Table 6.

8. Discussion

Recent research has shed some light on the influence of human resource management practices on innovation performance at the level of the firm. This notwithstanding, gaps remain in our knowledge about the likely mechanisms thereby management strategies bear on innovation. This paper argues that in order to tackle this shortcoming research needs to fine tune the way it normally addresses the issues involved. It is pertinent to better understand the way management practices condition learning processes of individuals involved in innovation activities inside the firm.

From the literature, we identified a series of learning strategies available for firms to acquire technology either through in-house efforts and/or from external knowledge sources. Technology acquisition is interpreted broadly as learning. We then looked at the pharmaceutical industry in Mexico as a case study. In line with recent scholarly work, we found a significant share of firms in the industry implementing a mix of internal and external strategies for technology acquisition. This supports the notion that firms need to develop adequate technological bases in-house in order to access and benefit from external sources of knowledge. Even more so if they are to eventually contribute to the progression in the technological complexity of their environment. Unfortunately, data limitations prevented us to perform a proper analysis of the impact of the chosen learning strategy on actual innovation

performance. ENESTyC provides absolutely no information about customary innovation output indicators.

The analysis however, provided some evidence on the influence that management practices supportive for individual learning may have on broader learning strategies at the level of the firm. We showed in particular, the importance of wage compensation to support either an internal only strategy or, combinations of both internal and external schemes. Likewise, we found that provision of training from external agents is a relevant mean to complement whatever efforts firms may undertake in-house. These findings are consistent with previous studies suggesting that in countries like Mexico, training opportunities and adequate compensation may lead to improved performance by the labour force. Moreover, it is likely that whenever firms characterise by low or in fact, R&D efforts of a moderate complexity, further progression in research capacities necessarily requires interaction with other more specialised and experienced agents.

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FDA Definitions Federal Drug Administration. http://www.fda.gov/cder/about/smallbiz/definitions.htm
GPWI Las Mejores Empresas para Trabajar en México Great Place to Work Institute Mexico. http://www.greatplacetowork.com/best/list-mx.htm
IMS-Health http://www.imshealth.com/